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FERTILIZATION OF FISH PONDS

Prepared in the Division of Fishery Bilogy

The number of ponds constructed on farms throughout the country has increased amazingly during the past three or four years. Although complete figures are not obtainable, these farm fish ponds undoubtedly are numbered by tens of thousands and represent a potential source of a significant quantity of food.

The poundage of fish yielded by an individual pond depends largely upon how much fish food is available inits waters. Mostpondfish eat smaller fishes, water insects, and small crustacea; these, in turn, are dependent upon minute water plants for foods. These plants, most of which are of microscopic size, are unable to grow unless certain chemicals, especially nitrogen, phosphorous, and potash are present in the water in sufficient quantities. If the pond receives water that drains a rich and fertile soil, it may contain an adequate supply of these necessary chemicals and yield as much as 200 pounds of fish per acre. Ordinarily, however, it is desirable, or even essential, to improve upon natural conditions by the use of fertilizers, thus insuring favorable conditions for rapid growth. By proper fertilization the productive capacity of ponds may be enormously increased, the gain in fish production ranging from 50 percent in naturally poorer waters to a threefold increase in ponds draining rich soils.

The general principles of pond fertilization here outlined are applicable to the numberous ponds maintained by State and Federal fish hatcheries, as well as to privately owned and operated farm ponds.

In principle, pond fertilization is similar to the fertilization of land, but the procedure to be followed differs in several details. In land fertilization the soil acts as a storehouse in which the fertilizer is held temporarily until utilized by plants. In ponds, however, the fertilizing elements go into solution in a short time and if not utilized immediately may be carried away and lost.

It must be emphasized that just as various soils need different fertilizers for best results so diverse bodies of water may vary in their requirements. Unfortunately, however, we have little factual information on the particular combination of fertilizers that will give the best results in various types of water. Consequently, theonly safe course is to use

a so-called "complete" fertilizer. The process of pond fertilization is complicated by the evidence that not all fish respond equally well to the same fertilizer. Even if fertilizers that contain all of the essential elements in proper proportion are employed, the kind of fertilizer to be used may depend, to some extent at tleast, on the species and size of fish present.

ORGANIC AND INORGANIC FERTILIZERS

Both organic and inorganic fertilizers have been used in ponds with satisfactory results. Of the organic fertilizers, stable manure is probably best known, but has two very serious disadvantages. In the first place, it varies so widely in composition that it is impossible to make definite recommendations regarding the amount to be used. Secondly, unless great care is exercised in its use, serious depletion of the dissolved oxygen in the pond is likely to result, with a consequent loss of fish by asphyxiation. These objections do not apply to dried manures which can be obtained in any quantity desired and have been used with satisfactory results.

Cottonseed, soybean, and peanut meals are probably the most satisfactory organic fertilizers. Formerly, it was recommended that these meals be used alone in fertilizing fish ponds, but recent studies indicate that production can be increased by the addition of inorganic fertilizers such as superphosphate and lime.

The inorganic fertilizers are similar to those applied to field crops. They may be purchased in the form of a complete fertilizer or may be mixed by the user.

CHOICE OF FERTILIZER

In the Service's earlier experiments a combination of dried sheep manure and superphosphate was used with excellent results. The most satisfactory mixture consisted of equal parts sheep manure and superphosphate. The superphosphate should contain 16 percent of available phosphoric acid. Later it was found that an equal amount of cottonseed meal, soybean meal, or peanut meal could be substituted for sheep manure with little change in the results. Since the cost of sheep manure, cottonseed meal, soybean meal, and peanut meal is approximately the same, it is largely a matter of personal preference which product is used.

There is increasing evidence that inorganic fertilizers are superior to organic fertilizers. The nutrient elements are more readily dissolved in the water and produce their effects almost at once. Furthermore, the use of inorganic fertilizers apparently offers greater opportunities for the control of the large submerged vegetation. Experiments at Leetown, W. Va., during the past 3 years have revealed combinations which will prohibit or actually eliminate the growth of Chara and Potamogetons by stimulating the growth of forms of algae which smother them out or otherwise prevent them from growing.

Recently Swingle and Smith at the Alabama Agricultural Experiment Station have been conducting extensive experiments with inorganic fertilizers.

They orginally recommended the following 7-8-2[1/] mixture as giving most satisfactory results:

40 pounds sulphate of ammonia
60 pounds superphosphate (16 percent)
5 pounds muriate of potash
30 pounds basic slag, or
15 poundsfinely ground limestone

The basic slag or limestone is added to neutralize the acid formed when the ammonium sulphate is broken down andprobably will be unnecessary in waters containing considerable quantities of lime.

More recently Swingle and Smith have recommended a ready-mixed 6-8-4 fertilizer to which 10 pounds of nitrate of soda (in soft waters) or 10 pounds of ammonium sulphate (in hard waters) are to be added to each 100 pounds of the fertilizer. The above amounts are sufficient for one application to an acre of water. With the use of this fertilizer Swingle and Smith reported annual yields up to 400 pounds of fish per acre. This is a remarkable high production and probably cannot be realized under ordinary conditions.

The advisability of adding larger amounts of nitrogen andpotash to the inorganic fertilizer combinations, particularly in hard waters, is indicated by recent experiments a Leetwon where a 12-5-5 combination set a record production of 262 pounds of fingerling bass per acre and by the recent publications of Swingle and Smith in which nitrogen and potash ratios have been increased.

AMOUNT OF FERTILIZER REQUIRED

The amount of fertilizer required for best results will, of course, depend on local conditions. A pond that is naturally productive will require less fertilizer than one that is relatively unproductive. Furthermore, ponds with considerable overflow will require more fertilizer than those in which there is little loss of water. When using a dry organic or inorganic fertilizer from 500 to 1,000 pounds per acre for the season ordinarily will be sufficient. In ponds notably lacking in fertility larger amounts may be used to advantage, but as a rule this is not necessary and simply results in waste.

COMPOSITION AND APPLICATION OF FERTILIZER

Tables 1 and 2 list single fertilizers and combinations of fertilizers which should give satisfactory results when used as recommended. At present, it is impossible to make definite recommendations as to which fertilizer to use and the fish-culturist should select the one that seems best suited to his particular needs. Only by experimentation can be determine which will consistently give best results under his conditions.

1/ The active elements in a fertilizer are nitrogen, phosphorus, and potash. The characteristics of an individual fertilizer depend on the proportions of these substances, which are indicated by numerals. Thus a "7-8-2 mixture" contains 7 parts nitrogen to 8 parts phosphorus to 2 parts of potash.

They ordinarily are recommended the following 7-7-7/ mixtures as giving more satisfactory results:

50 pounds superphosphate (18 percent)
5 pounds muriate of potash
10 pounds basic slag, or
15 pounds finely ground limestone

The basic slag or limestone is added to neutralize the acid formed when the ammonium sulphate is broken down and nitrogen will be unavailable in warm crumbly condition for available quantities of time.

For tobacco, both in and field have recommended a ready-mixed 0-7-7 fertilizer to which 100 pounds of nitrate of soda (in dark weather) or 50 pounds of ammonium sulphate (in dark weather) are to be added to each 100 pounds of the fertilizer. The above amounts are sufficient for one application to an acre of water. With the use of this fertilizer Swiss and Dutch reported annual yields up to 500 pounds of fish per acre. This is a remarkable yield production and probably cannot be fished under ordinary conditions.

The advisability of adding larger amounts of nitrogen compared to the inorganic fertilizer combinations, particularly in heavy waters, is indicated by recent experiments in Denmark where a 14-7-7 combination gave a record production of 672 pounds of fish per acre and by the record production of Swingle and Smith in which nitrogen and potash ratios have been increased.

AMOUNT OF FERTILIZER TO APPLY

The amount of fertilizer required for best results will, of course, depend on local conditions. A good start is certainly worthwhile, but heavy less fertilizer than one that is relatively unproductive. Furthermore, ponds with considerable overflow will require more fertilizer than those in which there is little loss of water. When using a dry mixture or inorganic fertilizer from 500 to 1,000 pounds per acre for the season ordinarily will be sufficient. In ponds normally low in fertility larger amounts may be used to advantage, but as a rule this is not necessary and is injurious in many.

CONCLUSION AND APPLICATION OF THE RESULTS

Tables 1 and 2 list single fertilizers and combinations of fertilizers which should give results when used as recommended. At present, it is impossible to make definite recommendations as to which fertilizer to use and the rate which should be used for any other pond, but rather to give principles which by experimentation in individual ponds will probably give the best results under his conditions.

1/ The active ingredients in a fertilizer are nitrogen, phosphorus, and potash. The concentration of an individual fertilizer is used as the proportions of these ingredients, which are indicated by numerals. Thus a "7-7-7 mixture" contains 7 parts nitrogen to 8 parts phosphorus to 7 parts of potash.

For convenience in describing methods of application, the fertilizers have been divided into two groups, the organic and the inorganic fertilizers. In applying these fertilizers to hatchery nursery ponds the applications should be made at more frequent intervals than when fertilizing farm ponds. In both cases it is recommended that at least three consecutive fertilizations be made at weekly or 10-day intervals at the beginning of the season. In nursery ponds, fertilization should begin from three weeks to a month before the fry are introduced, while the fertilization of farm ponds should begin when the water temperature begins to rise in the spring. The total amount of fertilizer applied to farm ponds during a season need not be any greater than for nursery ponds.

When using organic fertilizers the water may become turbid from decay of organic matter. If this occurs, fewer applications should be made to avoid depletion of the oxygen content of the water.

With inorganic fertilizers, comparatively heavy applications are made early in the season to stimulate the development of "water bloom" or of filamentous algae. After a water bloom develops, the fertilizer need be added only often enough to maintain the bloom. In some hard waters a bloom may never appear, but certain species of filamentous algae will develop instead. In this event fertilizations should be made less frequently to hold the algae in check and leave some open water in the pond.

These filamentous algae appear to serve the same purpose as water blooms in preventing excessive growth of the larger aquatic plants which apparently rob ponds of much of their capacity to produce fish. Fertilization can be suspended after about 100 to 120 days in nursery ponds and after about September 1 in farm ponds.

METHOD OF APPLYING FERTILIZER

In small ponds up to several acres in area the fertilizer is applied by walkin along the bank and broadcasting toward the deeper water. On windy days the materials should be moistened. No attempt need to be made to cover the pond completely because wave action will distribute the materials. Caution should be exercised to keep the fertilizer away from the margin of the pond because its application in this area encourages the growth of weeds. The fertilizer should be confined to water from one to five feet in depth. Material falling into deeper water is utilized very slowly by the plankton. In larger ponds the fertilizer is broadcast from boats.

In applying barnyard manure the usual method has been to spread the manure in shallow water along the pond margins. This method, however, has serious disadvantages and better results are usually obtained if the manure is left in piles. Nelson (1941) recommends dumping the manure in the center of thepond in piles totaling about 3 tons per acre. Leslie Bennett at the Fairport, (Iowa) station used 2 tons per acre distributed about the ponds in crates 6'x3'x2½'.

If the manure is not to be used at once, it should be stored under cover to prevent leaching. If this is impracticable, leaching may be reduced to a minimum by making the pile decidedly concave on top to hold the water and building up the sides vertically. Loss of nitrogen may be prevented by adding gypsum at the rate of 100 pounds to a ton of manure. This results in the formation of ammonium sulphate, which is non-volatile.

For convenience in distributing methods of application, the fertilizers have been divided into two groups, the inorganic and the organic fertilizers. In applying these fertilizers to brackish nursery ponds the following steps should be made at more frequent intervals than the fertilizing dose ponds. In both cases it is recommended that at least three consecutive fertilizations be made at weekly or 10-day intervals at the beginning of the season. In nursery ponds, fertilization should start three days prior to a month after the fry are introduced, while the fertilization of dose ponds should begin when the water temperature begins to rise in the ponds. The total amount of fertilizer applied to dose ponds during a season need not be any greater than for nursery ponds.

When using organic fertilizers the water may become turbid from decay of organic matter. If this occurs, fewer applications should be made to avoid depletion of the oxygen content of the water.

With inorganic fertilizers, comparatively heavy applications are made early in the season to stimulate the development of "water bloom" or of filamentous algae. After a water bloom develops, the fertilizer need be added only often enough to maintain the bloom. In some bare waters a bloom may never appear, but certain species of filamentous algae will develop instead. In this event fertilizations should be made less frequently to hold the algae in check and leave some open water in the pond.

These filamentous algae appear to serve the same purpose as water bloom in preventing excessive growth of the larger aquatic plants which sometimes rob ponds of much of their capacity to produce fish. Fertilization can be suspended after about 120 to 150 days in nursery ponds and after about September 1 in dose ponds.

METHODS OF APPLYING FERTILIZER

In small ponds up to several acres in area the fertilizer is applied by walking along the bank and broadcasting, toward the center, on windy days the material should be released. No attempt need be made to cover the pond completely because wave action will distribute the material. Caution should be exercised to keep the fertilizer away from the margin of the pond because its application in this zone encourages the growth of weeds. The fertilizer should be confined to water from one to five feet in depth. Material falling into deeper water is soluble only by the plankton. In larger ponds the fertilizer is broadcast from boats.

In a dying nursery pond the usual method has been to spread the manure in shallow water along the pond margins. This method, however, has serious disadvantages and better results are usually obtained if the manure is left in piles. Nelson (1941) recommends dumping the manure in the corner of dry pond in piles totaling about 2 tons per acre. Leslie Bennett of the Burpee, (Iowa) station used 2 tons per acre distributed about the ponds in groups of 100 pounds.

If the manure is not to be used at once, it should be stored under cover to prevent leaching. If this is impracticable, manure may be reduced to a slurry by mixing the pile decidedly copious to soak the water and puddling as one stirs vegetables. Loss of nitrogen may be prevented by adding gypsum at the rate of 100 pounds to a ton of manure. This results in the formation of ammonium sulphate, which is non-volatile.

Table 1.--Application of Organic Fertilizer

Kind of fertilizer	Ponds per acre per application	Frequency of applications (nursery ponds)	Approximate number of applications during a season (nursery ponds)	Kind of water
Cottonseed meal	50	Every 7 days for first 7 weeks; 14 days thereafter	14	Soft or moderately hard
Soybean meal	50	do	14	do
Peanut meal	50	do	14	do
Cottonseed meal (2 parts); 16 percent superphosphate (1part)	50	do	14	do
Cottonseed meal (1 part): 16 per cent superphosphate (1 part)	50	do	14	do
Dried sheep manure (1 part): 16 percent superphosphate (1 part)	50	do	14	do
Horse or fresh cow manure	1,000 first application; 500 thereafter	Every three weeks	6	do

Table 2.--Application of Inorganic Fertilizer

Kind and compostion of fertilizer	Pounds per acre per application	Frequency of application	Kind of water
Inorganic 12-5-5, per application: 60 lbs. ammonium sulphate (20.57 percent N) 30 lbs. superphosphate (16 percent P_2O_5) 10 lbs. muriate of potash (50 percent K_2O)	100	Every 10 days for first 3 applications; monthly thereafter or as often as necessary	Hard
Inorganic 8-7-2,1/ per application: 40 lbs. ammonium sulphate (20.57 percent N) 60 lbs. superphosphate (16 percent) 5 lbs. muriate of potash (50 per cent K_2O)2/ 15 lbs. finely ground limestone 10 lbs. nitrate of soda (16 percent N)	130	Weekly for first 3 weeks. As often as necessary thereafter. 3/	Soft
Inorganic 9-8-2,1/ per application: 50 lbs. ammonium sulphate (20.57 percent N) 60 lbs. superphosphate (16 percent P_2O_5) 5 lbs. muriate of potash (50 percent K_2O)	115	Weekly for first 3 weeks. As often as necessary thereafter.3/	Hard

1/ Recommended by Swingle and Smith.

2/ Swingle and Smith do not show ~~toptash~~ Potash content of the muriate of potash used in their work. Five pounds of 50 percent K_2O in muriate of potash would yield only 2 percent potash in the combination. Commercial muriate of potash contains from 48-62 per cent K_2O, but is usually offered at 50 percent. Swingle and Smith offer as an alternate to this 100 pounds of 6-8-4 inorganic fertilizer plus 10 pounds of nitrate of soda for use in farm ponds.

3/ Swingle and Smith recommended 3 or 4 applications of inorganic fertilizer at weekly intervals or until a "bloom" appears in the water. At this time the water becomes murky and green or brown due to the growth of the plnakton. Later applications should be made when the bottom becomes visible at 12-18 inches (approximately every 4 weeks.) In farm ponds the last application should be made in September.

Table 6.--Abbreviations of insecticide materials

Ring and combination of materials	:	Abbreviations
Ring No. 1		Ring No. 1
Ring No. 2		Ring No. 2

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